International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 7, Issue 3, Jun 2017, 79-86

DESIGN AND IMPLEMENTATION OF THE SMART FIRE EXTINGUISHER SYSTEM

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ABSTRACT

Objectives

The fire occurs frequently in our life and can lead to major accidents including life and property damage. We develop the system to fight the fire in the case of fire.

Methods/Statistical Analysis

We analyzed the cases of the fire accidents and the fire extinguisher around us. The fire can be extended to the accident if there is no person or if we don't fight quickly when it occurs. If there aren't any people around, the fire causes a fatal accident because we can't put out the initial fire appropriately. And there are dry powders in the fire extinguisher, the powder become hard after a long time.

Findings

Through our analysis, it is clear that we can minimize the damage if we fight well initial fire and it is effective to use a fire extinguisher furnished in a certain space of the building. Therefore, in this paper, we propose the smart fire extinguisher system which uses a fire extinguisher in a certain space of the building. The smart fire extinguisher system proposed in this paper consists of three modules such as sensing module, control module and operating module. The sensing module detects a fire using three types of sensors such as five flame sensors, a smoke detection sensor and motion detection sensor. And then control module instructs an operating module to spray the powder of the fire extinguisher. However, if there are people around when a fire occurs, people can operate the fire extinguisher to extinguish the fire themselves. So, to detect a person near to the fire extinguisher, we add the human body detection sensor to the sensing module and through this, our system can stop a fire extinguisher operation.

Improvements/Applications

In this paper, we propose the method of firefighting using the fire extinguisher. Through this system, we can automatically manage the powder and spray a powder to the position of fire.

KEYWORDS: Fire Extinguisher, MCU, Sensor, Motor & Motion

Received: Mar 30, 2017; **Accepted:** Apr 24, 2017; **Published:** May 04, 2017; **Paper Id.:** IJMPERDJUN201710

Original Article

1. INTRODUCTION

The fire occurs in unexpected cases or by carelessness of the person. The fire occurs frequently in our life and can lead to major accidents including life and property damage if it occurs [1,2,3]. In other words, if no action is taken properly when the fire occurred, this can result in a large fire. The fire can be prevented by a fast response

and using the correct extinguishing method. The fire can be extended to the accident if there is no person or if we don't fight quickly when it occurs. If there aren't any people around, the fire can be expanded to accident because the initial fire can't put out appropriately. The damage can be large-scale even though people don't respond rapidly. The fire in the building or structure is the highest rates of the types of fire. In addition, the fire occurring due to the carelessness is at least 50% of fire ignition factor. Therefore, we should be careful when using articles which will become an ignition factor and it is important to prepare thoroughly beforehand for fire prevention. On the other hand, it is principle that fire extinguisher is furnished for fire protection based on the fire services act, but in many cases people don't know how to use a fire extinguisher or there are in a state of neglect, not being used properly[4,5,6,7]. In other words, the loss of life and number of fire accidents is increasing because fire extinguisher is not managed and in a state of neglect. In this paper, we develop the smart fire extinguisher system which is available automatic injection. Through this system we can use a fire extinguisher in a certain space of the building to extinguish the initial fire and save both life and property.

The remainder of this paper is organized as follows. Section 2 describes a brief-overview of motor and sensing control. Section 3 presents the structure of smart fire extinguisher system. Section 4 shows system implementation results. Section 5 is conclusion.

- **Motor Control**

The electric motor is an energy conversion device that converts electric energy to mechanical energy, such as rotary or linear motion energy. The motor includes the AC motor, DC motor, BLDC motor, stepping motors and etc. AC motor changes the rotation speed by changing the frequency. DC motor changes the voltage applied to the armature. BLDC motor is a DC motor which eliminates the mechanical contact and installs the electronic rectification mechanism. The stepping motor controls signal by using the stepping motor driver for the precise angle and location. In general, we have to the motor driver in order to control the motor, the MCU is essential to control the motor driver. In this paper, we use ATmega128 AVR 8-bit microcontroller (produced by Atmel)[8].

ATmega128 has Advanced RISC Architecture structure and supports 128k Bytes of In-System Self-programmable Flash program memory, 4Kbytes EEPROM and 4Kbytes Internal SRAM. And by providing JTAG interface, ATmega128 has boundary-scan capabilities according to the JTAG standard. Figure 1 shows the architecture of ATmega128 module.

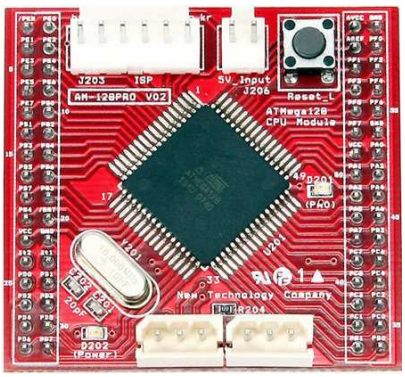

Figure 1: The Architecture of at Mega128 Module

- **Sensing**

The sensor is a device whose purpose is to detect changes in its environment, and then provide a corresponding output. Namely, the sensor converts changing value of the physical environment information to electrical signal and the physical environment information includes temperature, humidity and illumination. These sensors perform a role to collect the information of the surrounding environment in conjunction with various machines. Sensor for collecting the simple environment information is the temperature, humidity, illumination, ultrasonic, gas and acceleration sensor, and in this paper we use flame and smoke sensor to detect fire within a restricted zone, additionally use motion sensor to control a fire extinguisher.

- **Firefighting**

In the event of fire, in any case, it leads to disaster. Firefighting is not only lifesaving and evacuee guidance to protect people's life and property from fire but also the extinguishment and combustion protection [9,10]. In other words, rapid extinguishment can minimize the damage of people's life and property and the protection operation for the spread of fire is performed to avoid secondary damage. In general, we can minimize the damage if we fight well initial fire and it is effective to use a fire extinguisher furnished in a certain space of the building. In this paper, we develop a smart fire extinguisher to fight the initial fire when the fire occurs.

2. DESIGN

The smart fire extinguisher system proposed in this paper consists of three modules such as sensing module, control module and operating module. The basic structure of the whole system shows in the Figure 2.

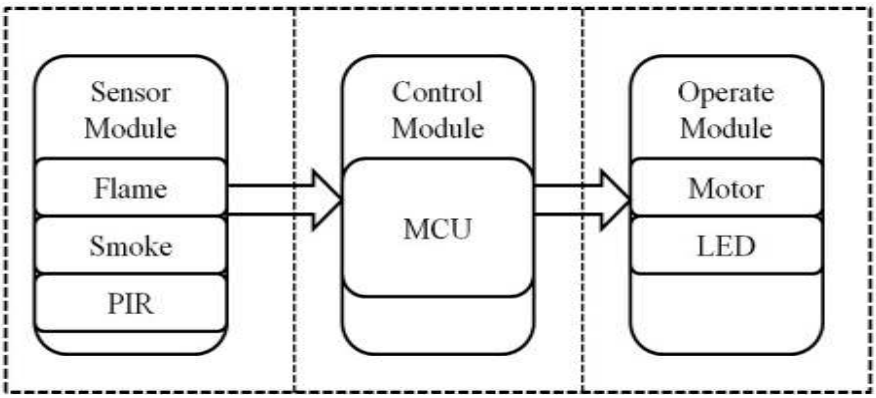

Figure 2: The Structure of the Whole System

The sensing module consists of three sensors. The sensing module is the operating part when the fire occurs. Three sensors are a flame sensor, a smoke detection sensor and a motion sensor.

- **Flame Sensor**

Flame sensor is used for detecting fire or spark file [11,12,13]. This can detect the flame or the wavelength at 760~1100nm range. The sensing distance is 50~80cm. PCB size is 32mm x 14mm. Figure 3 shows flame sensor module.

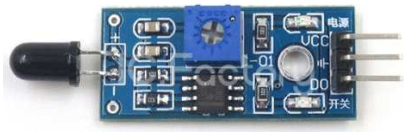

Figure 3: Flame Sensor Module

- **Smoke Detection Sensor**

Smoke detection sensor is measured using a change in the ionic current[14,15,16]. Detection range is 0.3~5%/foot and response time is within 3 seconds. Operating temperature is –20□~50□ and humidity is 0~95% R.H. The color of the smoke is not affected. Figure 4 shows smoke sensor module.

Figure 4: Smoke Sensor Module

- **Motion Sensor**

A motion sensor detects moving objects, particularly people[17]. An electronic motion sensor contains an optical, microwave, or acoustic sensor, and in many cases a transmitter for illumination. In this paper, we use a PIR (passive infrared) type sensor. PIR sensor is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. In other words, PIR motion Sensor can detect the infrared signals from human body or other animals and triggers with movement. Working current is 15uA and working temperature is -20~85□. Recognition angle is 100 degrees and recognition distance is 7m. Figure 5 shows motion sensor module.

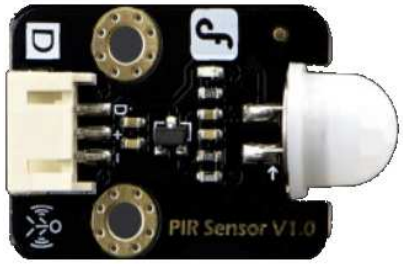

Figure 5: Motion Sensor Module

In general, fire is a phenomenon that combustible material reacts with oxygen to generate heat and light and burns. The resulting fire smoke is the cause of death by suffocation as a toxic gas[18]. Therefore, the sensing module detects the initial fire through flame and smoke detection sensor. When a fire breaks out, the existing fire monitoring system operates regardless of the presence or absence of a person in the space. But if there are people in the fireplace, we can operate the

fire extinguisher to extinguish the fire ourselves. To detect a person near to the fire extinguisher, we added the human body detection sensor to the sensing module. Through this, if there are people around when a fire occurs, our system can stop a fire extinguisher operation. In other words, our system can prevent the spraying powder of the fire extinguishers to people when a person is detected near the fire extinguisher. Figure 6 shows a block diagram of the smart fire extinguisher system.

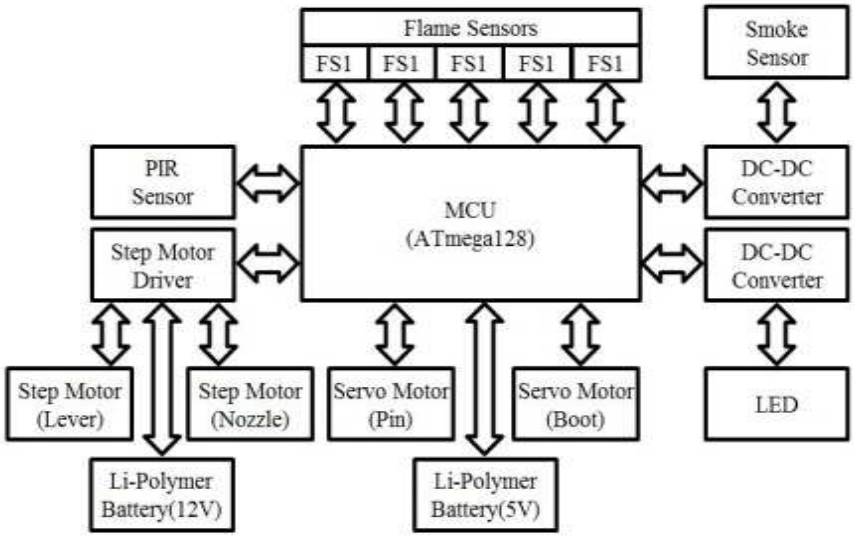

Figure 6: The Block Diagram of the System

3. IMPLEMENTATION

In this paper, we develop a smart fire extinguisher system using the latest IT technology. Using this system, a fire extinguisher furnished at the given space of the building enables the automatic fire fighting. Figure 7 shows the flowchart of our smart fire extinguisher system which is based on the two situations.

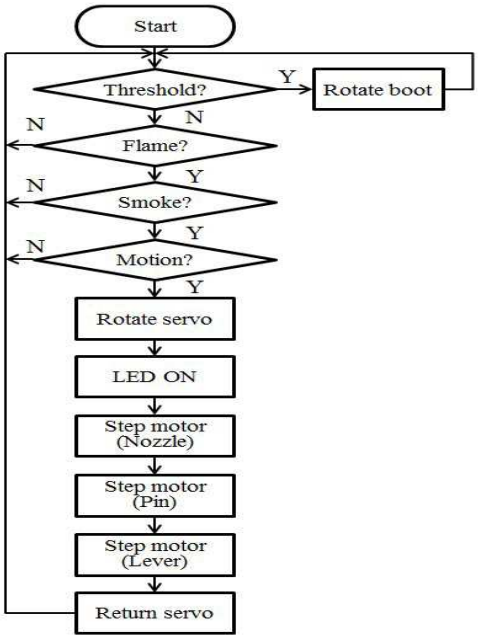

Figure 7: The Flowchart of the System

Since there are dry powders in the fire extinguisher, it has choking and cooling effect. The powder must be shook at regular intervals because of the hardness after a long time. In this system, by installing a servo motor in the holder joints of a fire extinguisher, servo motor usually does not work and rotates 90 degrees left and right in order to mix the powder per some weeks. Also, when a fire occurs, if our system recognizes the fire through a step-by-step test in the sensor module, it serves to move the fire extinguisher to the direction of fire in the range of 90 degrees left and right using servo motor. Figure 8 shows the servo motor which is mounted in the lower of fire extinguisher holder joint to work in the normal and in case of fire.

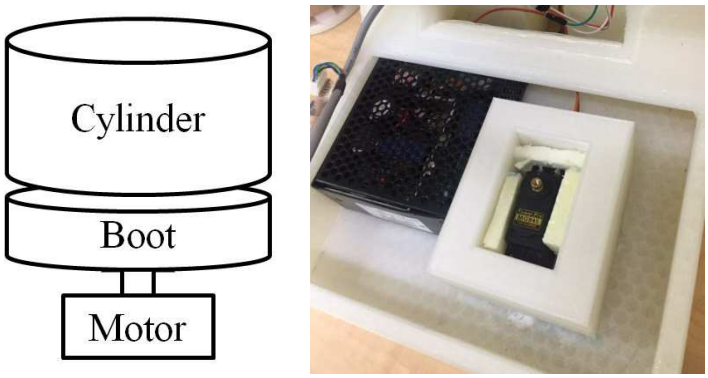

Figure 8: Servo Motor in the Lower

When a fire occurs, if the flame and the smoke detection sensor in the sensor module detects a fire, control module rotates the servo motor at the bottom and changes the direction to the detected position and turns LED On and Off ten times, and step motor in the top works and controls nozzle to the spray direction. And then, the servo motor in the top rotates to remove the safety pin and the step motor rotates to squeeze the lever and sprays the powder. Figure 9 shows for each motor operation on the top.

Figure 9: Motors on the Top

When the fire occurs, sensing module detects the fire and then control module instructs an operating module to spray the powder of the fire extinguisher. Figure 10 shows the control module.

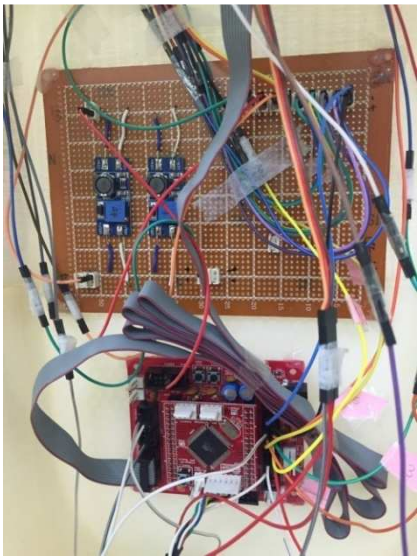

Figure 10: Control Module

Figure 11 shows the implementation of smart fire extinguisher system. We design the holder for the fire extinguisher using 3D modeling program and print out this holder with 3D printer.

Figure 11: The Implementation of the System

4. CONCLUSIONS

When a fire occurs, if a fire extinguisher is in the space but no people, it can't do an initial firefighting and the property damage is increased by it. In addition, there are many cases that failed the initial fighting because a fire extinguisher don't be managed and rusted and a powder is hardened. Therefore, we proposed the method of firefighting. In addition, we develop the smart fire extinguisher system which can automatically manage the powder and spray a powder to the position of fire. Through this system, we can fight the fire even if there are no people in the scene of a fire.

5. ACKNOWLEDGEMENTS

This study was supported by 2015 Research Grant from Kangwon National University (No. 201510006).

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